

**Survey of Northern Abalone, *Haliotis kamtschatkana*, Populations near Kitkatla,  
British Columbia, March 2000  
[Revised]**

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SURVEY OF NORTHERN ABALONE, *Haliotis kamtschatkana*,  
POPULATIONS NEAR KITKATLA,  
BRITISH COLUMBIA, MARCH 2000  
[REVISED]

by

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## ABSTRACT

Lucas, B.G., D. Brouwer, and A. Campbell. 2002. Survey of northern abalone, *Haliotis kamtschatkana*, populations near Kitkatla, British Columbia, March 2000 [Revised] Can. Manuscr. Rep. Fish. Aquat. Sci. 2622: 11 p.

A survey was conducted, during March 14 to 21, 2000, to provide an estimate of population numbers of mature emergent northern abalone in areas near Kitkatla, British Columbia. Abalone shell lengths (SL) ranged from 27 to 146 mm. The estimated mean density for abalone of all sizes was  $0.16/\text{m}^2$  at McCauley Island and  $0.05/\text{m}^2$  at Goschen Island. The estimated mean density for abalone 90 – 110 mm SL was  $0.05/\text{m}^2$  at McCauley Island and  $0.01/\text{m}^2$  at Goschen Island. The estimated mean total population number (and 90% confidence interval) of emergent abalone for all sizes at McCauley Island was 34,405 (18,291 – 50,520) and at Goschen Island was 20,750 (10,561 – 30,939). The mean total population number (and 90% confidence interval) of emergent abalone in the 90 – 110 mm SL size range was estimated for McCauley Island to be 11,326 (5,802 – 16,850) and for Goschen Island to be 4,000 (2,029 – 5,791).

## RÉSUMÉ

Lucas, B.G., D. Brouwer, and A. Campbell. 2002. Survey of northern abalone, *Haliotis kamtschatkana*, populations near Kitkatla, British Columbia, March 2000. [Revised] Can. Manuscr. Rep. Fish. Aquat. Sci. 2622: 11 p.

Un relevé a été effectué du 14 au 21 mars 2000 pour estimer l'effectif des populations d'ormeaux nordiques émergents matures près de Kitkatla (Colombie-Britannique). La longueur des ormeaux échantillonnés variait de 27 à 146 mm. La densité moyenne des ormeaux de toutes tailles a été estimée à  $0,16/\text{m}^2$  à l'île McCauley et à  $0,05/\text{m}^2$  à l'île Goschen. La densité moyenne estimée des ormeaux faisant de 90 à 110 mm de longueur était de  $0,05/\text{m}^2$  à l'île McCauley et de  $0,01/\text{m}^2$  à l'île Goschen. L'effectif total moyen de la population d'ormeaux émergents de toutes tailles a été estimé à 34 405 (intervalle de confiance à 90 % : 18 291 – 50 520) à l'île McCauley et à 20 750 (10 561 – 30 939) à l'île Goschen. Pour ce qui est des ormeaux faisant de 90 à 110 mm de longueur, leur effectif total estimé était de 11 326 (5 802 – 16 850) à l'île McCauley et de 4 000 (2 029 – 5 791) à l'île Goschen.



## INTRODUCTION

Northern abalone, *Haliotis kamtschatkana*, populations have declined in British Columbia (B.C.), despite complete closure of the fishery since 1990 for conservation purposes. Post-harvest surveys indicated that abalone densities were still well below levels recommended to ensure sustainable populations (Breen 1986, Campbell et al. 1998). The future of *H. kamtschatkana* was sufficiently uncertain that in April 1999 this species was declared "Threatened" by COSEWIC (Committee on the Status of Endangered Wildlife in Canada).

Fisheries and Oceans Canada (DFO), in cooperation with coastal communities and other interested stakeholders, has begun an initiative to rehabilitate abalone stocks in B.C. Collection of broodstock will be required to implement the first step in this program, which is to develop aquaculture technology for this species.

To estimate the abundance of abalone stocks in areas of interest, an independent assessment using conventional survey methodology was required. Only emergent (visible) abalone were surveyed to provide a minimum estimate of mature adult population numbers; cryptic abalone were not surveyed in this census.

The objectives of this study were to determine densities, size frequencies, and population numbers of emergent northern abalone at two locations near Kitkatla, B.C.

## MATERIALS AND METHODS

### FIELD METHODS

This survey was conducted during March 14 to 21, 2000 at McCauley Island and Goschen Island, B.C. (Figure 1). On McCauley Island, the area between Hankin Point and Baird Point was surveyed. On Goschen Island, the Joachim Spit area near Joachim Point was surveyed. Survey locations were selected, in consultation with Kitkatla First Nation's representatives, to include areas where abalone were most abundant. The transect survey method (Cripps and Campbell 1998) was used for this study. Transects were randomly placed along the lengths of shoreline, spit, or reef where populations were to be estimated. To avoid bias, these transect positions were determined in advance. The primary sampling unit was a "transect", made up of a cluster of secondary units. Each transect was one meter wide and variable in length, depending on the slope of the substrate. Prior to entering the water, a lead line was laid perpendicular to shore, spit, or reef from the boat in depths of approximately 12 m to 0 m from datum. Where negligible slope would have resulted in excessively long transects, a 100 m section within the 0 – 12 m depth range was haphazardly selected for surveying. The secondary sampling unit consisted of a 1 m x 1 m square quadrat that was placed along the transect, 1 m away, to avoid sampling areas disturbed by the lead line placement. Divers flipped the quadrat parallel to the transect line, from deep to shallow, and the number of "emergent" or "exposed" abalone, shell length (SL in mm) of each abalone, depth, substrate type, slope, and algal cover

was recorded. Algal cover, sea urchins and starfish were removed from the quadrat to ensure all emergent abalone were detected. Boulders were not moved to search for cryptic abalone, since the majority of mature abalone (i.e.,  $\geq 70$  mm SL) are exposed (Campbell 1996).

## ANALYTICAL METHODS

All gauge depths were converted to depth (m) at chart datum. The survey results were analyzed according to Fisheries and Oceans Canada methodology (Campbell et al. 1999). To determine the size frequency distribution for a location, the number of abalone in each 5 mm SL size class was divided by the total number of abalone in each location.

The estimated mean density,  $\bar{d}$  (number/m<sup>2</sup>), of abalone was calculated as:

$$\bar{d} = \frac{\sum_t (d_t * L_t)}{\sum_t L_t} \quad (1)$$

The standard error of the mean density,  $se_d$ , was calculated as:

$$se_d = \sqrt{1 - \frac{n}{T}} * \sqrt{\frac{\sum_t (d_t * L_t - \bar{d} * L_t)^2}{n * (n-1) * \bar{L}^2}} \quad (2)$$

where  $n$  is the number of transects,  $d_t$  is the mean density (number/m<sup>2</sup>) at transect  $t$ ,  $L_t$  is the length of transect  $t$  (or area in square metres since each transect is one metre wide),  $\bar{L} = \frac{\sum_t L_t}{n}$  is the mean transect length (or mean area in square metres), and  $T$  is the total possible number of transects that can be sampled in the surveyed area. The expression  $\sqrt{1 - \frac{n}{T}}$  is approximately one, because the sample size  $n$  is small compared to  $T$ . This method accounts for the variable length of transects and for the variable proportion of quadrats surveyed along each transect.

To estimate the mean density for a specific size group ( $J$ ), (e.g., 90 – 110 mm SL) the value  $d_t$  was substituted with densities ( $P_{t,J}$ ) in equations 1 and 2. The mean density  $P_{t,J}$  of abalone of size group  $J$  in transect  $t$  was calculated as:

$$P_{t,J} = \frac{\left( N_t * \frac{\sum_{i \in J} m_{t,i}}{M_t} \right)}{S_t} \quad (3)$$

where  $J$  is a subset (e.g., 90 – 110 mm SL) of possible  $i$  values representing a range of shell lengths ( $SL_i$ ),  $S_t$  is the number of quadrats surveyed for density estimates in transect  $t$ ,  $N_t$  is the number of abalone counted in transect  $t$ ,  $M_t = \sum_i m_{t,i}$  the total number of abalone measured for size in transect  $t$ , and  $m_{t,i}$  is the number of abalone in size range  $J$  of transect  $t$ .

The approximate lower 90% confidence interval of the mean density (L90CI) was calculated as:

$$L90CI = \bar{d} - t_{\alpha/2} \cdot se_d \quad (4)$$

where  $t_{\alpha/2}$  is the critical t-distribution value at degrees of freedom of  $n-1$ .

The total number of abalone ( $X$ ) in each location was calculated as:

$$X = \bar{d} \cdot A \quad \text{or} \quad X = L90CI \cdot A \quad (5)$$

where L90CI is the lower 90% confidence interval of the mean density for all sizes or for a particular size group of abalone, and  $A$  is the estimated area ( $m^2$ ) of the surveyed location. The area of the location surveyed was calculated as the product of the mean transect length (since transects generally covered the breadth of suitable abalone habitat) and the length of the location as measured by the distance between the two furthest points used when generating random transects.

## RESULTS

The area surveyed on McCauley Island was primarily well-sheltered shoreline and nearshore reefs. A few sites had moderate exposure to wind and storms. The substrate consisted of bedrock, boulders and sand (Table 1). The slope (angle from horizontal) was estimated to be from  $1^\circ$  to  $70^\circ$ . The area surveyed near Goschen Island was moderately exposed with strong tidal currents flowing through the area. A few sites were highly exposed to wind and storms. There was little slope to the substrate, which was mostly sand, with boulders, cobble and gravel near the spit and reef. High winds and rough seas during the survey period prevented surveying at Goschen Island on most days and in the most exposed areas. There was very little algal canopy in either area, because spring algal growth had only just begun in mid March when these surveys were conducted. The predominant canopy species was *Nereocystis*, with *Laminaria* dominating the understory. *Agarum*, *Alaria*, *Costaria* and *Fucus* were also present. Sea grass was found in patches, and rock substrates had a moderate cover of encrusted and articulated coralline algae. Few red sea urchins (*Strongylocentrotus franciscanus*) or sunflower starfish (*Pycnopodia*) were sighted during the survey.

The depths surveyed ranged from  $-3.4$  to  $15.7$  m from datum (Table 2). Thirty-three transects, with a mean length of 59 m, were surveyed near McCauley Island (Tables 2, 3). Sixteen transects were surveyed near Goschen Island, with a mean transect length of 110 m.

Three hundred twenty-two abalone were found in quadrats near McCauley Island and 83 in quadrats near Goschen Island, for a total of 405 abalone. Ten transects (20%) surveyed had no abalone. The maximum density for a transect was 1.07 abalone/m<sup>2</sup>. Sizes of abalone surveyed at McCauley Island ranged from 27 to 146 mm SL (Figure 2A) and from 28 to 128 mm SL at Goschen Island (Figure 2B). The mean size of abalone at McCauley Island was 86 mm SL and at Goschen Island was 80 mm SL. The size frequency histogram shows peaks at 45, 75, and 105 mm SL for McCauley Island, and at 65, 95, and 120 mm SL for Goschen Island.

Estimated mean total density of emergent abalone from McCauley Island was 0.16/m<sup>2</sup> and from Goschen Island was 0.05/m<sup>2</sup> (Table 4). The mean population estimate was 34,405 emergent abalone from McCauley Island and 20,750 from Goschen Island. Mean estimates of the number of abalone in the 90 – 110 mm SL size range were 11,326 for McCauley Island and 4,000 for Goschen Island.

## DISCUSSION

The abalone found in this survey had a wide range of sizes, with those at Goschen Island being evenly distributed throughout the range of sizes, and those at McCauley Island being normally distributed, with the majority in the 80 to 120 mm SL size range. The three peaks in each size frequency histogram, at evenly spaced 30 mm SL intervals, may be evidence of some natural recruitment to the populations in those areas. A conservative estimate of the total population numbers of emergent abalone of all sizes was provided by the lower 90% confidence interval (L90CI), which was 18,291 abalone for McCauley Island and 10,561 abalone for Goschen Island. The L90CI for mature emergent abalone 90 – 110 mm SL was 5,802 for McCauley Island and 2,029 for Goschen Island. The large uncertainty surrounding the estimated population means results, in part, from the small sample sizes. The lower confidence intervals provide more conservative estimates of population size than the mean estimates.

This survey provides no evidence of recovery of abalone populations since the province-wide closure in 1990. The abalone densities found during this survey were low at McCauley Island and at Goschen Island compared to most recent surveys in B.C. (Campbell et al. 1998, Lucas et al. 2002a, b, c). Since these low densities were well below those recommended to ensure sustainable populations (Breen 1986), the removal of any abalone from these areas must be considered with caution.

## ACKNOWLEDGMENTS

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## REFERENCES CITED

- Breen, P.A. 1986. Management of the British Columbia fishery for northern abalone (*Haliotis kamtschatkana*). Can. Spec. Publ. Fish. Aquat. Sci. 92: 300-312.
- Campbell, A. 1996. An evaluation of abalone surveys off southeast Queen Charlotte Islands. Can. Tech. Rep. Fish. Aquat. Sci. 2089: 111-121.
- Campbell, A., W. Hajas, and D. Bureau. 1999. Quota options for the red sea urchin fishery in British Columbia for fishing season 2000/2001. Can. Stock Assessment Secretariat Res. Doc. 99/201. 35 p.
- Campbell, A., I. Winther, B. Adkins, D. Brouwer, and D. Miller. 1998. Survey of the northern abalone (*Haliotis kamtschatkana*) in the central coast of British Columbia, May 1997. Can. Stock Assessment Secretariat Res. Doc. 98/99. 28 p.
- Cripps, K. and A. Campbell. 1998. Survey of abalone populations at Dallain Point and Higgins Pass, central coast of British Columbia, 1995-96. Can. Manuscr. Rep. Fish. Aquat. Sci. 2445: 31 p.
- Lucas, B.G., D. Brouwer, and A. Campbell. 2002a. Survey of northern abalone, *Haliotis kamtschatkana*, populations at Malcolm Island and Cormorant Island, British Columbia, October 1999. [Revised] Can. Manuscr. Rep. Fish. Aquat. Sci. 2620: 11 p.
- Lucas, B.G., A. Campbell, and D. Brouwer. 2002b. Survey of northern abalone, *Haliotis kamtschatkana*, populations in Lotbinière Bay, British Columbia, March 2000. [Revised] Can. Manuscr. Rep. Fish. Aquat. Sci. 2621: 11 p.
- Lucas, B.G., A. Campbell, D. Brouwer, S. Servant, and N. Webb. 2002c. Survey of northern abalone, *Haliotis kamtschatkana*, populations in southeast Barkley Sound, British Columbia, July 2000. [Revised] Can. Manuscr. Rep. Fish. Aquat. Sci. 2623: 11 p.

Table 1. Habitat summary for abalone transects surveyed in the Kitkatla area, March 14 – 21, 2000. The most common substrates are listed (1 = first, 2 = second, 3 = third) where substrate code 1 = smooth bedrock, 2 = bedrock with crevices, 3 = boulders, 4 = cobble, 5 = gravel, 6 = pea gravel, 7 = sand, 8 = shell, and 9 = mud. The average slope of the transect is estimated in degrees from horizontal. The algae present are listed by height strata (canopy = tall shading surface reaching, understory = 30 cm – 2 m, turf = 5 cm – 30 cm and bottom cover = < 5 cm) for the most common species (Sp 1) and second most common species (Sp 2) with the estimated percentage of cover (%) for each. AC = articulated coralline, AG = *Agarum*, AL = *Alaria*, B = unknown brown, CO = *Costaria*, EN = encrusting coralline, FU = *Fucus*, GR = sea grass, H = unknown filamentous, LA = *Laminaria*, MA = *Macrocystis*, NT = *Nereocystis*, PT = *Pterygophora*, and R = unknown red.

|                 |        | Algae     |   |   |                  |        |    |            |    |      |    |      |    |      |    |                 |     |
|-----------------|--------|-----------|---|---|------------------|--------|----|------------|----|------|----|------|----|------|----|-----------------|-----|
| Transect        | Date   | Substrate |   |   | Slope<br>degrees | Canopy |    | Understory |    |      |    | Turf |    |      |    | Bottom<br>Cover |     |
|                 |        | 1         | 2 | 3 |                  | Sp     | %  | Sp 1       | %  | Sp 2 | %  | Sp 1 | %  | Sp 2 | %  | Sp              | %   |
| McCauley Island |        |           |   |   |                  |        |    |            |    |      |    |      |    |      |    |                 |     |
| BB17            | Mar 20 | 4         | 3 |   | 5                |        |    | AG         | 70 | LA   | 10 | H    | 30 |      |    |                 |     |
| BB50            | Mar 20 | 2         |   |   | 25               |        |    | LA         | 5  | B    | 2  |      |    | AC   | 2  | EN              | 75  |
| BB60            | Mar 20 | 2         | 3 | 4 | 30               |        |    | B          | 5  | LA   | 2  | GR   | 2  | AC   | 40 | EN              | 50  |
| BB116           | Mar 20 | 7         | 2 | 4 | 45               |        |    | LA         | 20 |      |    |      |    |      |    | EN              | 20  |
| BB130           | Mar 20 | 2         | 3 | 4 | 45               |        |    | LA         | 5  | B    | 1  |      |    | AC   | 2  | EN              | 50  |
| BB171           | Mar 20 | 2         | 1 | 3 | 5                |        |    | LA         | 5  |      |    |      |    |      |    | EN              | 95  |
| BB187           | Mar 20 | 2         | 4 | 5 | 2                |        |    | LA         | 90 |      |    |      |    |      |    | EN              | 90  |
| BR305           | Mar 15 | 1         |   |   |                  |        |    |            |    |      |    |      |    |      |    | EN              | 100 |
| BR307           | Mar 15 | 1         | 7 |   | 30               |        |    | LA         | 2  |      |    |      |    | AC   | 5  | EN              | 75  |
| HN1             | Mar 21 | 2         | 8 | 3 | 45               | NT     | 1  | LA         | 10 | R    | 2  |      |    |      |    | EN              | 40  |
| HN2             | Mar 21 | 2         | 3 | 8 | 30               | NT     | 10 | LA         | 50 |      |    |      |    | AC   | 5  | EN              | 80  |
| HN3             | Mar 21 | 2         | 1 |   | 60               |        |    | AG         | 90 |      |    |      |    |      |    | EN              | 100 |
| HN4             | Mar 21 | 2         | 1 |   | 60               |        |    |            |    |      |    | AC   | 5  |      |    | EN              | 90  |
| HP6             | Mar 15 | 1         |   |   | 20               |        |    |            |    |      |    |      |    |      |    | EN              | 100 |
| HP56            | Mar 17 | 1         | 3 |   | 10               |        |    | LA         | 2  |      |    | AC   | 2  | H    | 90 | EN              | 10  |
| HP75            | Mar 15 | 1         | 5 | 7 | 5                |        |    | LA         | 10 |      |    | AC   | 5  |      |    | EN              | 2   |
| HP96            | Mar 17 | 3         | 7 | 1 | 5                |        |    | LA         | 2  |      |    |      |    |      |    | EN              | 70  |
| HP127           | Mar 15 | 7         | 1 | 3 | 25               |        |    | LA         | 5  |      |    |      |    | AC   | 2  | EN              | 15  |
| HP131           | Mar 17 | 2         | 7 |   | 40               |        |    | LA         | 10 |      |    |      |    | AC   | 5  | EN              | 50  |
| HP141           | Mar 17 | 1         | 3 | 7 | 5                |        |    |            |    |      |    |      |    | H    | 95 |                 |     |
| HP167           | Mar 17 | 1         | 2 |   | 5                |        |    | AG         | 70 |      |    |      |    |      |    | EN              | 90  |
| HP169           | Mar 17 | 1         | 2 | 7 | 5                |        |    | AG         | 70 |      |    |      |    |      |    | EN              | 70  |
| HP173           | Mar 15 | 1         | 7 |   | 30               |        |    | AG         | 5  |      |    |      |    |      |    | EN              | 30  |
| HP181           | Mar 17 | 7         | 3 | 2 | 20               |        |    | AG         | 40 | R    | 5  |      |    |      |    | EN              | 50  |
| HP182           | Mar 17 | 1         | 7 | 3 | 15               |        |    | AG         | 40 |      |    |      |    |      |    | EN              | 60  |
| SI1             | Mar 18 | 1         | 2 |   | 70               |        |    |            |    |      |    | GR   | 20 |      |    | EN              | 70  |
| SI10            | Mar 18 | 1         |   |   | 70               |        |    | AG         | 2  |      |    | LA   | 2  | AC   | 5  | EN              | 80  |
| SI38            | Mar 18 | 3         | 1 | 4 | 5                |        |    | LA         | 2  |      |    | GR   | 2  |      |    | EN              | 100 |
| SI50            | Mar 18 | 3         | 1 | 4 | 1                |        |    | LA         |    |      |    |      |    |      |    | EN              | 90  |
| SI60            | Mar 18 | 1         | 3 | 5 | 30               |        |    | FU         | 30 | LA   | 5  | GR   | 2  |      |    | EN              | 50  |
| SI72            | Mar 18 | 2         |   |   | 30               |        |    | LA         | 90 |      |    |      |    |      |    | EN              | 80  |
| SI88            | Mar 18 | 3         | 7 | 4 | 5                |        |    | LA         | 10 | B    | 5  | GR   | 2  | AC   | 10 | EN              | 20  |
| SI90            | Mar 18 | 3         | 4 | 1 | 10               |        |    | LA         | 5  | AG   | 1  |      |    |      |    | EN              | 5   |
| Goschen Island  |        |           |   |   |                  |        |    |            |    |      |    |      |    |      |    |                 |     |
| JP141           | Mar 19 | 3         | 4 | 5 | 0                |        |    | PT         | 50 | LA   | 20 | GR   | 2  |      |    |                 |     |
| JP143           | Mar 19 | 3         | 5 | 4 | 1                |        |    |            |    |      |    | GR   | 2  |      |    | EN              | 20  |
| JP160           | Mar 19 | 3         | 4 | 5 | 20               | NT     | 5  | R          | 25 | LA   | 10 | GR   | 5  | AC   | 1  | EN              | 2   |
| JP166           | Mar 19 | 3         | 4 | 7 | 15               | NT     | 10 | LA         | 20 | AL   | 5  | GR   | 5  | AC   | 10 | EN              | 30  |
| JP183           | Mar 16 | 3         | 7 | 5 | 5                |        |    |            |    |      |    | LA   | 20 | AC   | 20 | EN              | 100 |
| JP200           | Mar 16 | 7         | 4 | 3 | 1                |        |    | LA         | 1  |      |    | GR   | 1  | AC   | 2  | EN              | 2   |
| JP22            | Mar 14 | 3         | 7 | 4 | 3                | NT     | 10 | LA         | 25 |      |    | GR   | 1  | AC   | 1  | EN              | 25  |
| JP265           | Mar 19 | 4         | 5 | 3 | 0                |        |    | LA         | 10 |      |    |      |    | H    | 30 |                 |     |
| JP291           | Mar 19 | 7         | 4 | 3 | 2                | NT     | 1  | LA         | 10 | B    | 5  | GR   | 1  | AC   | 15 | EN              | 5   |
| JP31            | Mar 16 | 3         | 4 | 5 | 5                | NT     | 1  | LA         | 40 | CO   | 2  | GR   | 5  |      |    | EN              | 50  |
| JP365           | Mar 19 | 3         | 4 | 5 | 0                |        |    | LA         | 80 |      |    |      |    |      |    | EN              | 80  |
| JP58            | Mar 14 | 7         | 4 | 5 | 2                |        |    | LA         | 5  |      |    | AC   | 10 |      |    | EN              | 20  |
| JP71            | Mar 14 | 7         | 4 |   | 2                |        |    |            |    |      |    |      |    |      |    | EN              | 2   |
| JP72            | Mar 14 | 7         |   |   | 1                |        |    |            |    |      |    | GR   | 2  |      |    |                 |     |
| JP73            | Mar 14 | 7         | 4 |   | 2                |        |    | LA         | 20 |      |    | AC   | 60 | GR   | 5  |                 |     |
| JP90            | Mar 16 | 3         | 7 | 4 | 10               |        |    | LA         | 30 | AL   | 5  | GR   | 30 |      |    | EN              | 25  |

Table 2. Dive summary for abalone transects surveyed in the Kitkatla area, March 14 – 21, 2000.

| Transect        | Date   | Time  |        |        | Depth (m) |      | Number of<br>Quadrats | Number of Abalone |          | Density (#/m2) |          |
|-----------------|--------|-------|--------|--------|-----------|------|-----------------------|-------------------|----------|----------------|----------|
|                 |        | Start | Finish | Bottom | Min       | Max  |                       | all sizes         | 90-110mm | all sizes      | 90-110mm |
| McCauley Island |        |       |        |        |           |      |                       |                   |          |                |          |
| BB-17           | Mar 20 | 14:33 | 15:15  | 0:42   | -0.9      | 5.2  | 60                    | 11                | 4        | 0.18           | 0.07     |
| BB-50           | Mar 20 | 14:04 | 14:35  | 0:31   | 1.3       | 4.0  | 9                     | 8                 | 3        | 0.89           | 0.33     |
| BB-60           | Mar 20 | 13:14 | 13:46  | 0:32   | -1.8      | 4.3  | 60                    | 6                 | 3        | 0.10           | 0.05     |
| BB-116          | Mar 20 | 11:27 | 11:43  | 0:16   | -1.0      | 10.3 | 43                    | 2                 | 0        | 0.05           | 0.00     |
| BB-130          | Mar 20 | 10:45 | 11:10  | 0:25   | 0.0       | 7.9  | 26                    | 3                 | 0        | 0.12           | 0.00     |
| BB-171          | Mar 20 | 13:00 | 14:00  | 1:00   | -2.7      | 4.6  | 75                    | 38                | 10       | 0.51           | 0.13     |
| BB-187          | Mar 20 | 10:30 | 11:38  | 1:08   | -0.6      | 2.0  | 80                    | 69                | 28       | 0.86           | 0.35     |
| BR-305          | Mar 15 | 10:55 | 11:40  | 0:45   | -0.6      | 7.0  | 60                    | 0                 | 0        | 0.00           | 0.00     |
| BR-307          | Mar 15 | 10:58 | 11:40  | 0:42   | 1.2       | 11.0 | 96                    | 0                 | 0        | 0.00           | 0.00     |
| HN-1            | Mar 21 | 10:40 | 11:11  | 0:31   | 1.0       | 9.4  | 46                    | 6                 | 1        | 0.13           | 0.02     |
| HN-2            | Mar 21 | 11:37 | 12:30  | 0:53   | 0.8       | 6.5  | 45                    | 48                | 11       | 1.07           | 0.24     |
| HN-3            | Mar 21 | 10:30 | 11:10  | 0:40   | -1.1      | 8.4  | 25                    | 8                 | 1        | 0.32           | 0.04     |
| HN-4            | Mar 21 | 11:45 | 12:00  | 0:15   | -1.4      | 6.3  | 13                    | 8                 | 4        | 0.62           | 0.31     |
| HP-6            | Mar 15 | 14:00 | 14:40  | 0:40   | -0.5      | 12.2 | 71                    | 12                | 6        | 0.17           | 0.08     |
| HP-56           | Mar 17 | 10:30 | 11:10  | 0:40   | -0.6      | 5.4  | 90                    | 3                 | 2        | 0.03           | 0.02     |
| HP-75           | Mar 15 | 13:14 | 13:40  | 0:26   | -1.2      | 3.4  | 68                    | 0                 | 0        | 0.00           | 0.00     |
| HP-96           | Mar 17 | 15:08 | 15:50  | 0:42   | -1.0      | 6.4  | 85                    | 9                 | 2        | 0.11           | 0.02     |
| HP-127          | Mar 15 | 13:28 | 13:50  | 0:22   | 2.5       | 15.7 | 60                    | 4                 | 3        | 0.07           | 0.05     |
| HP-131          | Mar 17 | 13:32 | 14:25  | 0:53   | 1.7       | 11.7 | 53                    | 24                | 7        | 0.45           | 0.13     |
| HP-141          | Mar 17 | 11:35 | 12:00  | 0:25   | -2.2      | 4.7  | 120                   | 5                 | 3        | 0.04           | 0.03     |
| HP-167          | Mar 17 | 13:15 | 13:50  | 0:35   | -3.4      | 5.7  | 67                    | 10                | 4        | 0.15           | 0.06     |
| HP-169          | Mar 17 | 14:13 | 14:45  | 0:32   | -2.6      | 8.3  | 65                    | 1                 | 0        | 0.02           | 0.00     |
| HP-173          | Mar 15 | 14:30 | 14:54  | 0:24   | 3.0       | 13.5 | 49                    | 2                 | 1        | 0.04           | 0.02     |
| HP-181          | Mar 17 | 10:45 | 11:14  | 0:29   | -3.0      | 3.2  | 72                    | 1                 | 1        | 0.01           | 0.01     |
| HP-182          | Mar 17 | 11:38 | 11:58  | 0:20   | 1.7       | 6.8  | 23                    | 0                 | 0        | 0.00           | 0.00     |
| SI-1            | Mar 18 | 13:00 | 13:30  | 0:30   | -1.4      | 4.9  | 11                    | 0                 | 0        | 0.00           | 0.00     |
| SI-10           | Mar 18 | 14:00 | 14:20  | 0:20   | -0.9      | 7.0  | 13                    | 9                 | 1        | 0.69           | 0.08     |
| SI-38           | Mar 18 | 10:50 | 11:40  | 0:50   | -2.0      | 6.4  | 75                    | 14                | 6        | 0.19           | 0.08     |
| SI-50           | Mar 18 | 14:50 | 15:25  | 0:35   | -0.5      | 1.3  | 70                    | 9                 | 3        | 0.13           | 0.04     |
| SI-60           | Mar 18 | 11:05 | 11:42  | 0:37   | -3.1      | 2.0  | 100                   | 0                 | 0        | 0.00           | 0.00     |
| SI-72           | Mar 18 | 15:08 | 15:48  | 0:40   | 1.3       | 8.4  | 54                    | 11                | 2        | 0.20           | 0.04     |
| SI-88           | Mar 18 | 13:15 | 13:37  | 0:22   | -1.3      | 1.9  | 77                    | 1                 | 0        | 0.01           | 0.00     |
| SI-90           | Mar 18 | 14:09 | 14:38  | 0:29   | -1.3      | 2.7  | 100                   | 0                 | 0        | 0.00           | 0.00     |
| Goschen Island  |        |       |        |        |           |      |                       |                   |          |                |          |
| JP-22           | Mar 14 | 14:55 | 15:57  | 1:02   | 0.9       | 4.2  | 100                   | 20                | 1        | 0.20           | 0.01     |
| JP-31           | Mar 16 | 13:45 | 15:02  | 1:17   | -0.7      | 1.6  | 120                   | 12                | 3        | 0.10           | 0.03     |
| JP-58           | Mar 14 | 16:00 | 16:45  | 0:45   | -1.7      | 2.7  | 130                   | 1                 | 0        | 0.01           | 0.00     |
| JP-71           | Mar 14 | 13:35 | 14:10  | 0:35   | 0.8       | 1.7  | 135                   | 2                 | 1        | 0.01           | 0.01     |
| JP-72           | Mar 14 | 13:35 | 13:57  | 0:22   | 3.1       | 3.7  | 100                   | 0                 | 0        | 0.00           | 0.00     |
| JP-73           | Mar 14 | 14:45 | 15:35  | 0:50   | -1.1      | 1.5  | 120                   | 4                 | 1        | 0.03           | 0.01     |
| JP-90           | Mar 16 | 13:46 | 14:44  | 0:58   | -1.7      | 1.4  | 147                   | 1                 | 1        | 0.01           | 0.01     |
| JP-141          | Mar 19 | 10:30 | 11:30  | 1:00   | -0.6      | 2.1  | 100                   | 5                 | 3        | 0.05           | 0.03     |
| JP-143          | Mar 19 | 11:48 | 12:34  | 0:46   | -1.5      | 1.9  | 100                   | 10                | 2        | 0.10           | 0.02     |
| JP-160          | Mar 19 | 12:18 | 13:12  | 0:54   | -1.2      | 4.4  | 90                    | 3                 | 0        | 0.03           | 0.00     |
| JP-166          | Mar 19 | 10:48 | 11:48  | 1:00   | -1.2      | 4.7  | 117                   | 4                 | 1        | 0.03           | 0.01     |
| JP-183          | Mar 16 | 11:00 | 11:57  | 0:57   | -2.1      | 2.6  | 120                   | 3                 | 0        | 0.03           | 0.00     |
| JP-200          | Mar 16 | 11:15 | 11:35  | 0:20   | 3.7       | 4.3  | 100                   | 0                 | 0        | 0.00           | 0.00     |
| JP-265          | Mar 19 | 15:15 | 15:45  | 0:30   | 5.7       | 7.9  | 115                   | 4                 | 0        | 0.03           | 0.00     |
| JP-291          | Mar 19 | 14:48 | 15:08  | 0:20   | 3.1       | 4.4  | 65                    | 0                 | 0        | 0.00           | 0.00     |
| JP-365          | Mar 19 | 14:00 | 14:45  | 0:45   | 3.9       | 4.8  | 95                    | 14                | 3        | 0.15           | 0.03     |

Table 3. Summary statistics and area surveyed for transect survey of emergent abalone from the Kitkatla area, March 14 - 21, 2000. Values in brackets are standard errors.

| Details per transect                          | McCauley Island | Goschen Island |
|-----------------------------------------------|-----------------|----------------|
| Number of transects                           | 33              | 16             |
| Number of abalone                             | 405             | 122            |
| Mean transect length (m) & number of quadrats | 59.42 (4.90)    | 109.63 (4.96)  |
| Mean depth (m)                                | 3.46 (0.09)     | 1.80 (0.05)    |
| Mean minutes                                  | 34.88 (2.18)    | 46.31 (4.21)   |
| Mean minutes/quadrat                          | 0.81 (0.12)     | 0.42 (0.04)    |
| Length of shoreline or reef surveyed (m)      | 3,526           | 2,000          |
| Area surveyed (m <sup>2</sup> )               | 209,530         | 438,500        |

Table 4. Mean densities (number/m<sup>2</sup>) and population estimates of emergent abalone from the Kitkatla area, March 14 - 21, 2000. Values in brackets are 90% confidence intervals.

| Details per location       | McCauley Island          | Goschen Island           |
|----------------------------|--------------------------|--------------------------|
| Mean density all sizes     | 0.16 (0.09 - 0.24)       | 0.05 (0.02 - 0.07)       |
| Mean density 90-110 mm SL  | 0.05 (0.03 - 0.08)       | 0.01 (0.00 - 0.01)       |
| Total population all sizes | 34,405 (18,291 - 50,520) | 20,750 (10,561 - 30,939) |
| Population 90-110 mm SL    | 11,326 (5,802 - 16,850)  | 4,000 (2,029 - 5,791)    |

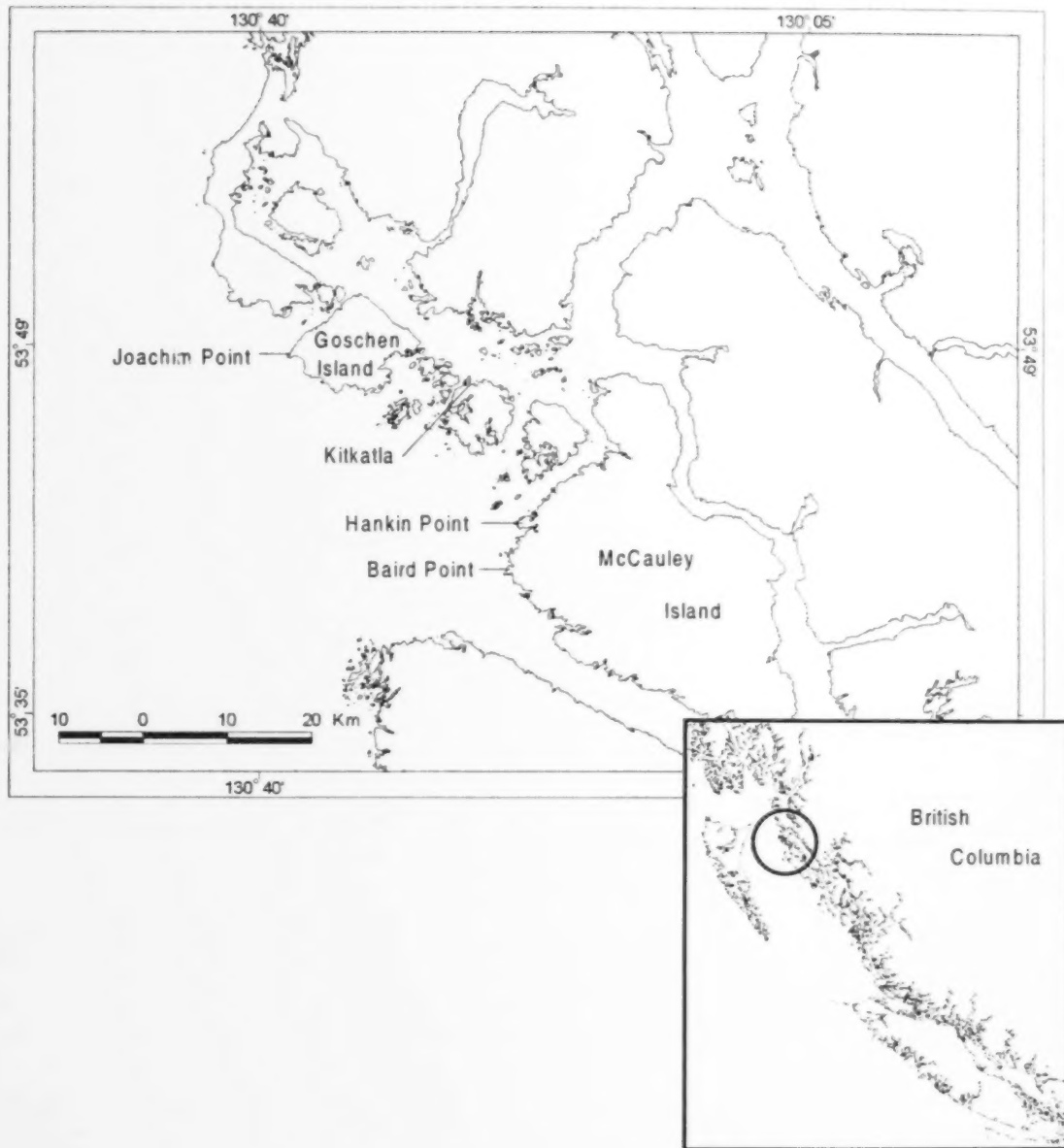


Figure 1. Abalone survey locations on McCauley Island, between Hankin Point and Baird Point, and on Goschen Island, near Joachim Point. The inset shows the area detailed near Kitkatla, British Columbia.

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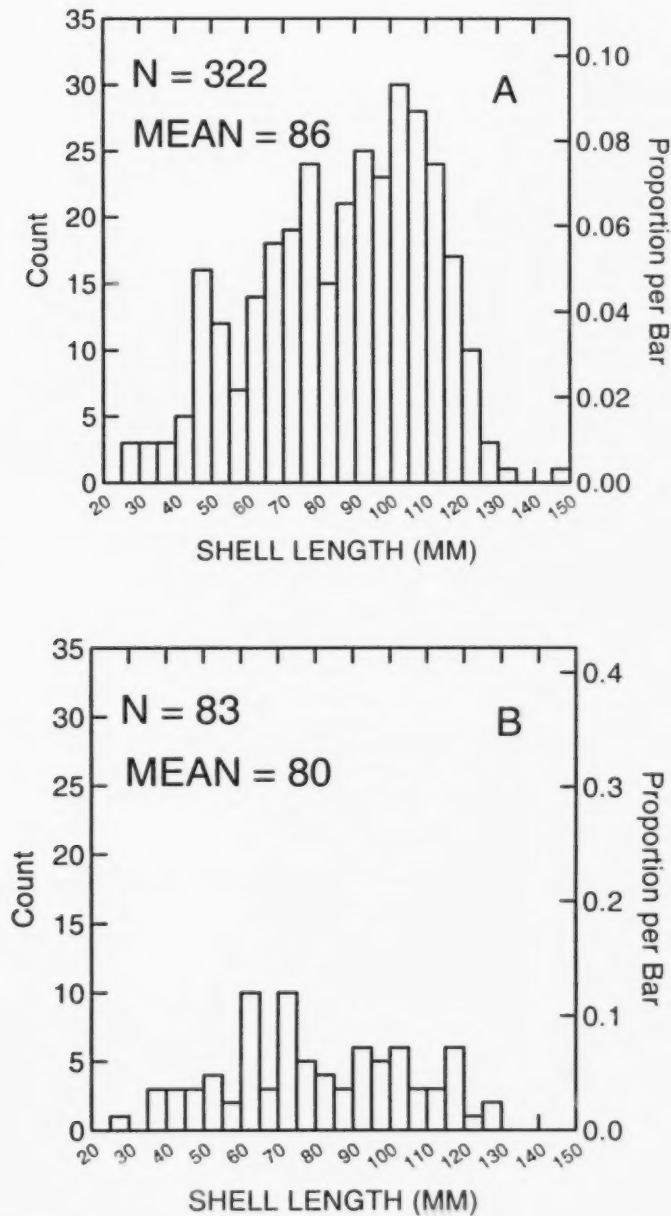


Figure 2. Size frequencies of emergent abalone found in quadrats during dive surveys in the Kitkatla area, March 14 – 21, 2000. Locations were (A) McCauley Island and (B) Goschen Island. Number of abalone (N) and mean shell length in mm are shown for each location.

